

Dredging Research

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Jun. 2003

International workshop participants take new look at resuspension of sediment due to dredging

Information based on Workshop report provided by James E. Clausner, ERDC Vicksburg, Coastal and Hydraulics Laboratory

Resuspension of sediment in the water column continues to be a topic of interest to the U.S. Army Corps of Engineers, the U.S. EPA, the U.S. Department of the Interior's Minerals Management Service (MMS), state resource agencies, and other stakeholders worldwide. For example, the Corps has funded research on resuspension during dredging since the 1970s, and recently MMS funded research on this topic. The Netherlands' responsible government agency (Rijkswaterstaat), with dredging contractors, is also funding research on resuspension, with other European countries showing interest in accurate predictions of resuspension due to dredging as a basis for sound regulatory policy. In addition, the EPA has funded some research on resuspension of contaminants during cleanup dredging and continues to fund research on desorption of contaminants from sediment particles.

Reasons for this interest are the potential negative impacts on biota and aesthetics.

Resuspension of sediment is a concern during maintenance dredging, mining of sand for beach nourishment, and especially during cleanup dredging of contaminated sediment. There is a need to develop high-quality models that predict resuspension. Data from such models will allow agencies to base dredging regulations on science and engineering research results.

Workshop kicks off sediment resuspension cooperative effort

On January 22, 2003, the Corps' ERDC Coastal and Hydraulics and Environmental

Laboratories hosted a 1-day workshop on resuspension of sediments due to dredging in Washington, DC. Recent ERDC studies have focused on improving plume measurement techniques, developing models for predicting resuspension at the dredge, and developing software that displays features of far-field resuspension plumes.

The purpose of the workshop was to allow U.S. participants from the Corps, EPA, MMS, and collaborating partners from abroad to learn the history, goals, status, and plans of each group's research efforts. Attendees included government, academia, and private sector representatives from here and abroad.

Presentations establish history of sediment resuspension research

Dr. Don Hayes, University of Utah, presented an overview of currently held views about resuspension issues. He addressed both problems and solutions.



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➤ **Problems.** Scientists have a reasonable feel for the significance and extent of dredging-induced sediment resuspension. However, availability of good quality data sets is limited. The few efforts to collect data are hampered by lack of long-range objectives, budget limitations, regulatory confusion, and narrowly defined interests.

➤ **Solutions.** Advancing the science will require clear problem definition; focus on long-term goals and desired outcomes; an interdisciplinary and multi-agency approach; a carefully constructed research plan; and substantial, persistent funding. Hayes described the four spatial scales associated with transport of resuspended sediment. He stated that the temporal scales, performance criteria, and regulatory controls associated with dredging-induced resuspension must balance productivity (i.e., project duration) with allowable water quality impacts. Criteria and controls should be based on science, not conjecture. Available data are limited. This limitation often leads to overly protective regulations. Improved data and models should lead to better regulatory frameworks. Measuring resuspension of sediments due to dredging with sufficient quality to allow use of the data for model development is difficult. The variety of dredges, operating variables, operators' skill level, hydrodynamics, and sediment characteristics greatly complicate developing robust models. Based on work in the 1970s, 80s, and 90s, some empirical techniques were developed. However, extrapolating these techniques to other dredges, sediments, and/or environments has proven to be problematic. Similarly, some simple models also were developed during that time frame.

These model are inadequate in many situations. Often, particularly with mechanical dredges, the resuspension plume is sporadic and generally never reaches steady-state.

Next, U.S. and foreign agency viewpoints on resuspension due to dredging were addressed as part of the workshop. Several speakers presented the state of research on a variety of subjects.

➤ James Clausner presented current Corps viewpoints on resuspension due to dredging. Corps history of resuspension research, with a considerable effort in the 1980s on measuring resuspension from a range of dredge types, focused mainly on maintenance dredging of clean sediments. Clausner also briefly described research on resuspension due to vessel passage. Finally, he described resuspension research performed under the Corps' Dredging Operations and Environmental Research (DOER) program that includes development of the Suspended Sediment FATE of dredged material model, SSFATE.

➤ Mr. Neville Burt from HR Wallingford addressed the European perspective, which includes the problems of regulations associated with resuspension due to dredging that are not based on sound science. The solution is to have good models for predicting resuspension. The weak link in developing models for predicting resuspension has been measuring source strength. HR Wallingford and Dredging Research Limited (DRL), both U.K. contractors to The Netherlands' Rijkswaterstaat, are now developing improved predictive models that require high-quality measurements of source strength. The Corps is collaborating on this research through

the DOER program. Burt said that under a contract with VBKO (consortium of Dutch dredging contractors) and the Rijkswaterstaat, his organization and DRL have developed a draft set of protocols for collecting high-quality resuspension data that can be used to improve predictive models. These protocols, monitoring tools, and techniques have been tested on a bucket and a hopper dredging project. Burt asked a number of representatives from European countries to review the protocols. The reaction to the protocols, and their purpose of developing good science for accurately predicting resuspension that will lead to sound regulations, has been quite positive. DRL updated the protocols based on review comments and experience gained during three dredging resuspension measurement field tests. A revised set of protocols was completed in March 2003.

➤ Mr. Hans Otten from the Rijkswaterstaat provided The Netherlands' government's perspective. The Netherlands do not have general standards for resuspension as it is believed that resuspension will be quite site specific. He acknowledged that detailed knowledge of resuspension source terms is lacking, as well as the related models. Without this information, there is no way to predict or control resuspension, and with this lack of a scientifically sound base of information, the Dutch government is not in a position to set standards for dredging industry compliance. This lack of information caused them to join with VBKO to support the effort on improved resuspension modeling. The primary product from the work will be the Turbidity Assessment Software (TASS), a publicly available model that

will predict the rate of release of sediment caused by dredging.

➤ Mr. Barry Drucker, MMS, described work ongoing at his agency to determine environmental impacts associated with hopper dredging of aggregates. Much of this research has been done in conjunction with HR Wallingford and other British companies. The United Kingdom uses hopper dredges to mine 30 percent of their aggregates.

➤ Dr. Steven Ells, EPA, provided a short introduction on EPA's research needs, including prediction of resuspension of contaminated sediment during cleanup dredging; prediction of water column dissolved and particulate contaminant concentrations and their impact on biota; and the efficacy of silt screens to control resuspension over a range of conditions. Dr. William (Skip) Nelson described measurement of resuspension on the New Bedford Harbor superfund cleanup project.

New tools for predicting resuspension and measuring contaminant release

The second set of technical presentations focused on recently developed tools, primarily models, for predicting resuspension and for displaying results and techniques when measuring resuspension.

➤ In his presentation on dredging source terms, Hayes described a change in terminology. He described a zone immediately around the dredge head that includes mixing induced by the movement of the head, and suggested (after some discussion) this region be called the zone of initial dilution (ZID). Hayes described problems with resuspension data sets and the turbidity generation unit (TGU) method. He also described potential solutions, including the

resuspension factor approach, empirical methods, and transient modeling and its implications, and provided a table describing modeling complexity. Under contract to the Corps' DOER program, Hayes will develop an improved matrix of basic resuspension factors that can be used as source strength input by models like the Corps' SSFATE. These factors will take the basic resuspension rate and modify it to account for factors such as cycle time (production rate), bucket size, and adjustments for sediment properties.

➤ Mr. Eric Anderson of Applied Science Associates (ASA) described the Corps' model SSFATE. SSFATE was developed initially under contract by ASA for the Corps' DOER program, providing a tool for biologists to show the extent of a plume and allow them to negotiate environmental windows with state regulators. SSFATE's source terms are based on older algorithms, but it now includes advanced and easy-to-use plume tracking and display capabilities. Plans are to develop improved source strength models for easy incorporation into SSFATE, along with other improvements. Dr. Joseph Gailani, ERDC-CHL, presented a sophisticated application of SSFATE where it was used to predict impacts of mixed sediments placed in the nearshore off Tybee Island, GA.

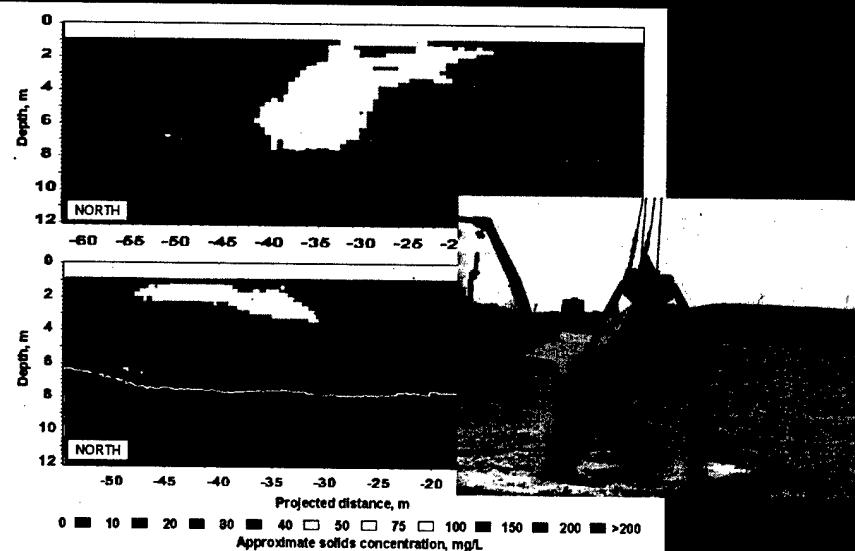
➤ In his second presentation, Burt noted that an improved version of TASS being developed by HR Wallingford and DRL has now been completed. TASS includes a complete analysis of the dredging processes and originally planned to look at all five types of dredges. Initial efforts focused on the grab (mechanical) dredge. Recently, work has focused on trailing suction hopper dredges. Future efforts

include more work on the bulldozing effect of the draghead and additional field measurements.

➤ John Land, DRL, discussed field calibration of TASS based on resuspension plume measurements. The objectives were to measure all the sediments released, establish a "characteristic release rate," quantify release from different stages of the dredging process, and relate the rate of sediment release to the dredging process (soil; dredge type, manner of operation, etc.). Land noted the following characteristics of dredge plumes: concentrations are extremely variable; the plumes may be small (<10 m wide close to the dredge); they may be temporally very variable/intermittent; and sediment may settle quickly to the bed. Land discussed consequences for release measurement, then went on to describe the primary methods for measuring plumes for all dredges except trailing suction hopper dredges. Land then described the methods required for hopper dredges. Included were results from a number of projects including the Tees River, where measurements on a mechanical dredging operation were repeated to determine the effect of air entrainment on measurements.

➤ Based on Hayes' and Land's presentations, Clausner developed the following summary. Tools, techniques, and protocols for making good quality measurements have been lacking in the past. Improvements are being made, particularly the use of broad band acoustic Doppler profilers (ADCPs) (combined with high-quality software for converting acoustic backscatter to total suspended solids (TSS)) supplemented with optical backscatter (OBS) gage readings and ground truthed with TSS

Grab hoisting and grab leakage plumes



Resuspension plume from a grab dredge as measured by ADCP

measurements from water samples. ADCPs allow the closely spaced TSS measurements needed for model development. Near field collection of resuspension data using OBS gages and water samples has been demonstrated for bucket and cutterhead dredges. However, safely operating around working dredges of most types continues to be dangerous. Collecting data of sufficient quality has been and will continue to be quite expensive in most cases. Basic definitions of sediment loss, and the spatial and temporal limits on which to define loss, have not yet been widely accepted.

➤ Mr. Douglass Scott from Baird and Associates, Ltd., described a model under development by contract to MMS for predicting the resuspension plume and sedimentation characteristics associated with trailing suction hopper dredges when mining aggregates and beach quality

sand from U.S. Federal Waters. In addition to Baird & Associates, the development team includes HR Wallingford (plume model development and testing), DRL (dredging process algorithms), Coastline Surveys Limited (monitoring data for model evaluation), and Marine Ecological Survey, Ltd (dredging impacts). Dredging operations source terms include TSS associated with overflow and the drag head. The model performance evaluation is now in progress as is sensitivity testing and model adjustment.

Additional workshop activities

Under sponsorship by EPA and the Corps, the Hazardous Substances Research Center (HRSC) Southwest, located at Louisiana State University, has investigated desorption of contaminants from sediment particles. Dr. Louis Thibodeaux of LSU summarized the current research. The "Hockey Stick" desorption model for chemi-

cal solubilization from suspended particles is a simple mathematical algorithm that describes the behavior of contaminant release from sediment particles. This algorithm can be applied to polycyclic aromatic hydrocarbons, other hydrocarbons, polychlorinated biphenyls, chlorinated solvents, pesticides, and metals (eventually). Research has shown that the loosely bound contaminants, which comprise the larger amount of the chemical mass, are released rapidly (hours), while the more tightly bound contaminants are released much more slowly. A plot of the release amount versus time resembles a hockey stick.

Following the formal presentations, an open discussion of possible collaborations on future research was conducted. There was a strong consensus to continue coordination and collaborative efforts. EPA representatives agreed to fully cooperate in this effort on resuspension.

At the conclusion of the meeting, Dr. Robert E. Engler, Senior Scientist for the Environment, ERDC-EL, directed Clausner and Dr. Douglas Clarke, ERDC-EL, to develop a framework that describes research needed, priorities, and some idea of costs. Contaminant loss issues and associated models (as described by Thibodeaux) will be considered. Burt and Hayes volunteered to make a first cut at this framework that will be provided to DOER as well as upper Corps and EPA management to assist in identifying and setting priorities for future research.

Additional information is available by contacting Jim Clausner at James.E.Clausner@erdc.usace.army.mil. Comments from other sources are encouraged.

Worm gut fluids may yield key to assessing contaminant bioaccumulation potential in dredged materials (Part 2)

By Rod Millward, ERDC Vicksburg, Environmental Laboratory, contractor support

A quick recap

The measurement of bioaccumulation potential – the availability of potentially hazardous contaminants to accumulate in living organisms – is central to quality assessment of dredged materials. Even in cases where bioaccumulation is not expected to be associated with detrimental effects to benthic organisms, predation upon these benthic organisms can lead to biomagnification up the food chain, eventually including humans. Therefore, assessment of bioaccumulation potential in benthic organisms is essential when considering risk within the human population.

However, assessment of bioaccumulation potential for contaminated sediments is far from straightforward. Only a limited proportion of the total sediment-associated contaminants is available for absorption into organisms, due to the activity of various sorption phases within sediments.

Obviously, the most direct way to assess bioaccumulation is to measure contaminant concentrations in representative organisms using a standard exposure test. However, such tests are expensive and laborious, particularly in cases of multiple contaminants.

Recent work by Dr. Donald Weston (U.C. Berkeley), Dr. Laurence Mayer (U. Maine), and colleagues aims to develop a simple alternative to such tests. Studies have suggested that a key factor controlling the uptake of some contaminants from sediments into organisms is the solubilization of contaminants from sediments. The work of Weston and Mayer builds on this principle: if the degree to which contaminants are solubilized in gut fluids determines bioaccumulation, it follows that contaminant concentrations extracted from sediments by gut fluid should predict contaminant body burdens. Recent studies at ERDC



Editor's Note: A previous edition of *Dredging Research* (September 2002) introduced how worm gut fluids might help predict bioaccumulation potential of contaminants in dredged materials. In this edition, the topic continues using new data gathered at the ERDC Vicksburg Environmental Laboratory investigating whether gut fluids do indeed help predict bioaccumulation.

Vicksburg have explored this possibility, investigating whether the solubilization of both organic and metal contaminants from sediments by gut fluid is a good predictor of bioaccumulation.

Gut fluid solubilization

Drs. Rod Millward and Gui Lotufo of ERDC-EL examined the ability of gut fluid extracts to predict bioaccumulation of contaminated sediments. Gut fluids collected from large invertebrate worms (Fig. 1) were used to extract sediments contaminated with either polycyclic aromatic hydrocarbons (PAH) or metals. Extraction procedures involved placing around half a gram of wet sediment into a few milliliters of gut fluid, mixing well, and then leaving for 1 to 2 hours with constant agitation. The gut fluid can then be removed by centrifugation and decanting the supernatant, and analyzed for the contaminant of concern. The same



Figure 1. The marine worm *Arenicola brasiliensis*, used for gut fluid collection

sediments were used in simultaneous bioaccumulation tests with the polychaete worm *Neanthes arenaceodentata* (Fig. 2). Finally, the correlations were investigated between contaminant concentrations in the gut fluid and the worm to test whether gut fluid extraction might be used to predict bioaccumulation.

Results: Can gut fluid extraction predict bioaccumulation?

Gut fluid extraction did a fair job in predicting PAH bioaccumulation, confirming the findings of previous studies. However, prediction of metal bioaccumulation proved more problematic. While gut fluid extraction provided useful estimates of bioaccumulation for some metals (e.g., arsenic, nickel, chromium, and lead), it proved unreliable as a predictor of others (e.g., cadmium, copper, silver, and zinc). While reasons for these ambiguous, metal-specific trends are not clear, it is likely that metal bioaccumulation is controlled by more com-

plex processes than gut fluid metal concentrations alone. The team continues to explore how that technique might be improved upon, including the development of a synthetic gut fluid mimic.

The conclusion is as follows: while gut fluid extractions might offer some potential in predicting bioaccumulation of organic contaminants, present gut fluid extrac-

tion methods are unlikely to offer a reliable alternative to standard bioaccumulation tests, at least in the foreseeable future.

Additional information is available from Rod Millward at Roderic.N.Millward@erdc.usace.army.mil.

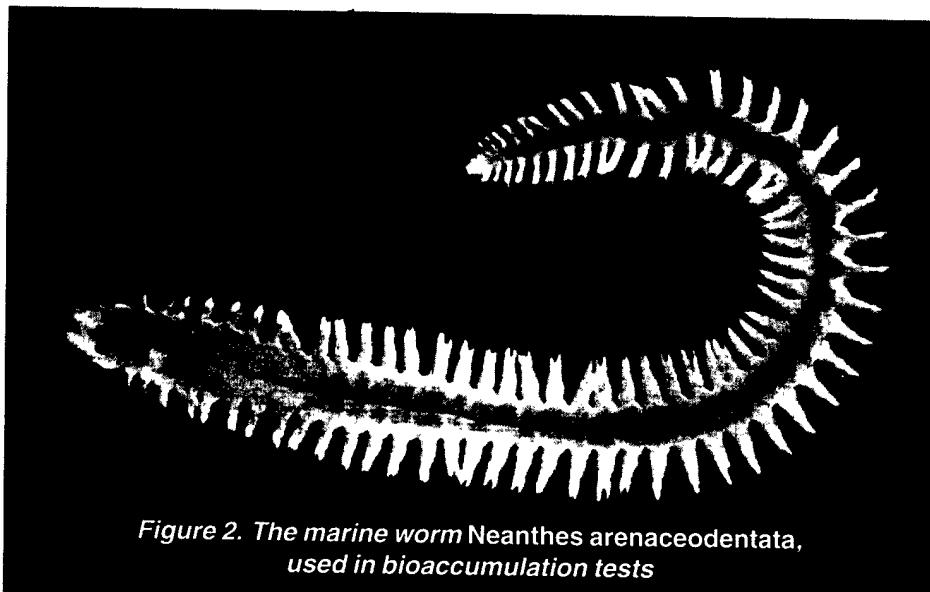


Figure 2. The marine worm *Neanthes arenaceodentata*, used in bioaccumulation tests

Articles for *Dredging Research* requested:

Dredging Research is an information exchange bulletin for publication of ERDC-generated dredging research results. Included are articles about applied research projects. The bulletin serves all audiences and is accessible on the World Wide Web in addition to a paper circulation of 2,800. Articles from non-ERDC authors are solicited for publication, especially if the work described is tied to the use of ERDC-generated research results. Research articles that complement ERDC research or cover wide field applications are also accepted for consideration. Manuscripts should use a nontechnical writing style and should include suggestions for visuals and an author point of contact. Point of contact is Elke Briuer, APR, at Elke.Briuer@erdc.usace.army.mil.

Dredging Calendar

2003

June 30, 2003 – Replies to authors

November 30, 2003 – Deadline for full papers

August 2-6, 2004 – International Symposium on *Sediment Transfer Through the Fluvial System*, Moscow, Russia. Sponsored by The International Association of Hydrological Sciences (IAHS), International Commission on Continental Erosion (ICCE), and co-sponsored by Moscow State University. Contact and information: Valentin Golosov or Vladimir Belyaev at tel. 007-095-9395044, fax 007-095-9395044.

June 4-6 – OI Americas 2003. Morial Convention Center, New Orleans, USA. To receive further information contact www.woda.org or CEDA, P.O. Box 488, 2600 AL Delft, Netherlands, tel. +31 15 278 3145, fax +31 15 278 7104, email: ceda@dredging.org.

June 11-13 – WEDA XXIII and Texas A&M's 35th Annual Dredging Seminar, Chicago. Program theme is *The Dredging Contractor*. For additional information contact Lawrence M. Patella, tel. 360-750-0209, fax 360-750-1445, or visit www.westerndredging.org.

July 13-17 – Coastal Zone 03, Baltimore. Convention Center located in the Inner Harbor District at One West Pratt Street. Theme of conference is *Management Through Time* (port and harbor; regional land; management response to coastal hazards (erosion); and management of aquatic resources). More information can be found at www.csc.noaa.gov/cz2003/information.html.

August 24-28 – Coastal Structures 2003

Conference. Portland, Oregon, Embassy Suites, downtown. More information can be found at <http://www.asce.org/conferences/coastal2003/>.

October 1 – Title and abstract due for WODCON XVII. See more information below, under 2004. *Call for Papers* (PDF - 704 KB).

November 9-13 – SETAC 24th Annual Meeting in North America. *Science Without Borders: Developing Solutions for Global Environmental Challenges*. Austin Convention Center, Austin, Texas. More information can be found at <http://www.setac.org/austinmain.html>.

2004

May 23-26 – ASCE's Ports 2004: Port Development in a Changing World. Houston, Westin Galleria and Westin Oaks. More information can be found at www.asce.org/conferences/ports2004.

September 27-October 1 – WODCON XVII, *Dredging in a Sensitive Environment*, Hamburg, Germany. *Invitation to Post Congress Tour* (PDF - 232 KB). POC: Anna Caiti, P.O. Box 488 2600 AL Delft, The Netherlands, email: ceda@dredging.org. More information can be found at www.woda.org, click on "congresses."



U.S. Section PIANC Annual Meeting

Roundtable on Protecting America's Ports from Natural and Man-made Disasters

Technical Workshops On Wetlands Restoration and Passing Vessel Issues

October 28 – 30, 2003
Portland, Oregon



Preliminary Program

Monday, October 27

6:00 to 8:00 PM Reception

Tuesday, October 28

Morning: U.S. Section PIANC Annual Meeting

Afternoon: Roundtable Discussion:
All Hazard Risk Management for Ports and Harbors

Protecting America's Ports from Natural and Man-Made Disasters

Ports and harbors have always faced some level of risk to both natural and technological hazards, such as oil spills. The events of September 11th added a new level of complexity to hazard risk management decision-making. Senior Leaders from the port industry, the Corps of Engineers, and the Coast Guard will conduct an interactive discussion with audience members on how the ports and harbors community is prepared to manage risks associated with natural, technological or malevolent-act hazards.

Evening Boat Trip on the Willamette River sponsored by the Port of Portland

Wednesday, October 29

8:00 to 5:00

Wetlands Restoration Workshop

The conflict between navigation systems and wetlands is a significant problem on essentially all navigation infrastructure. The loss of wetlands through the construction and maintenance of navigation infrastructure, including the placement of dredged material, must be considered in

managing navigation systems. This workshop will provide a forum for:

1. International discussion of state-of-the-science methods for wetland restoration
2. Findings of the PIANC working group regarding wetland restoration
3. Significant research gaps
4. Identification of areas of collaboration and potential stakeholders

Organizer: Dr. Russell Theriot, ERDC

1:00 to 5:00

Passing Vessel Issues Workshop

The effects of moving vessels have become an issue of increasing concern in designing and managing our navigable waterways. The latest efforts and research regarding the effects passing vessels have on safety, engineering design and the environment will be presented. This workshop will provide a forum for:

1. International discussion of state-of-the-art methodologies, models, and measurement techniques;
2. Definition of research gaps; and
3. Identification of areas of collaboration and potential stakeholders.

Organizer: Dr. Sandra Knight, ERDC

Evening: Commissioners' Meeting

Thursday, October 30

8:00 to 5:00 Continuation of Vessel Effects Workshop

The Venue

Workshops will be held at the Portland Marriott Downtown, situated in the "City of Roses" on the west bank of the scenic Willamette River.

1401 SW Naito Parkway

Portland, OR 97201

Phone: 503-226-7600

Or 800-228-9290

Fax: 503-221-1789

www.portlandmarriott.com

A block of rooms is being held under the name International Navigation Association (PIANC) Technical Workshops until October 6, at the rate of \$90.00. Participants should contact the hotel directly and make their reservations prior to October 6.

Registration Form

Name: _____

Address: _____

Phone: _____

Email: _____

Please check the appropriate functions:

Annual meeting/Roundtable _____
Wetland Restoration Workshop _____
Passing Vessel Issues Workshop _____

Registration Fees include meals and
Social Functions

	PIANC	nonmember
Annual Mtg/Roundtable	\$100	\$200
1 Workshop	\$100	\$200
Annual mtg + 1 wkshp	\$175	\$300
Both Workshops	\$175	\$300
Annual Mtg + 2 wkshps	\$250	\$350

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Individual Membership \$80 _____

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Dredging Research

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